

WHAT IS CLAIMED IS:

1. A method of forming a bottom electrode of a magnetic memory cell, comprising:
 - depositing a pinning layer over a workpiece;
 - depositing a soft layer material over the pinning layer;
 - depositing a first hard mask over the soft layer material, the first hard mask comprising a conductive material;
 - patterning the first hard mask;
 - using the first hard mask to pattern the soft layer material and form at least one magnetic memory cell;
 - depositing a second hard mask over the first hard mask and exposed portions of the pinning layer, the second hard mask comprising a dielectric material having a Young's modulus greater than the Young's modulus of silicon dioxide;
 - patterning the second hard mask; and
 - using the second hard mask to pattern the pinning layer and form a bottom electrode.
2. The method according to Claim 1, wherein depositing the second hard mask comprises depositing SiC, SiON, SiCN or SiN.
3. The method according to Claim 1, wherein depositing the second hard mask comprises depositing 500 to 2500 Angstroms of material.
4. The method according to Claim 1, wherein depositing the first hard mask comprises depositing TiN.

5. The method according to Claim 4, further comprising depositing a third hard mask over the first hard mask, prior to patterning the first hard mask, wherein patterning the first hard mask further comprises patterning the third hard mask.
6. The method according to Claim 5, wherein depositing the third hard mask comprises depositing SiO_2 .
7. The method according to Claim 1, further comprising:
 - depositing a first insulating layer over the second hard mask; and
 - planarizing the workpiece to remove portions of the first insulating layer from over a top surface of the first hard mask.
8. The method according to Claim 7, wherein depositing the first insulating layer comprises depositing SiC , SiON , SiCN or SiN .
9. The method according to Claim 7, wherein depositing the first insulating layer comprises depositing the first insulating layer in a thickness greater than the top surface of the first hard mask.

10. The method according to Claim 7, further comprising:

before depositing a pinning layer, forming at least one first conductive line over the workpiece;

depositing a second insulating layer over the at least one first conductive line adjacent the pinning layer;

forming at least one via in the second insulating layer, the via abutting and making electrical contact to the at least one first conductive line and the pinning layer;

depositing a third insulating layer over the first hard mask top surface and the first insulating layer; and

forming at least one second conductive line in the third insulating layer, wherein the at least one second conductive line makes electrical contact to an upper portion of the magnetic memory cell.

11. The method according to Claim 1, wherein depositing the soft layer material comprises depositing a first magnetic layer over the pinning layer, depositing a thin oxide layer over the first magnetic layer, and depositing a second magnetic layer over the thin oxide layer, wherein the at least one magnetic memory cell comprises a magnetic random access memory (MRAM) cell.

12. The method according to Claim 1, wherein after patterning the pinning layer, at least a portion of the second hard mask remains residing over at least the patterned soft layer sidewalls and a top surface of the first hard mask.

13. A method of manufacturing a magnetic memory device, comprising:

providing a workpiece;

depositing a first insulating layer over the workpiece;

forming at least one first conductive line in the first insulating layer;

depositing a second insulating layer over the at least one first conductive line and first insulating layer;

forming a via within the second insulating layer, the via abutting the at least one first conductive line;

depositing a pinning layer over the via and second insulating layer;

depositing a soft layer material over the pinning layer;

depositing a first hard mask over the soft layer material, the first hard mask comprising a conductive material;

patterning the first hard mask;

using the first hard mask to pattern the soft layer material and form at least one magnetic memory cell;

depositing a second hard mask over the first hard mask and exposed portions of the pinning layer, the second hard mask comprising a dielectric material having a Young's modulus greater than the Young's modulus of silicon dioxide;

patterning the second hard mask;

using the second hard mask to pattern the pinning layer;

depositing a third insulating layer over the second hard mask, the third hard mask comprising a dielectric material having a Young's modulus greater than the Young's modulus of silicon dioxide; and

planarizing the workpiece to remove portions of the third insulating layer from over a top surface of the first hard mask.

14. The method according to Claim 13, wherein depositing the second hard mask comprises depositing SiC, SiON, SiCN or SiN, and wherein depositing the third insulating layer comprises depositing SiC, SiON, SiCN or SiN.

15. The method according to Claim 13, wherein depositing the second hard mask comprises depositing 500 to 2500 Angstroms of material.

16. The method according to Claim 13, wherein depositing the first hard mask comprises depositing TiN.

17. The method according to Claim 13, further comprising depositing a third hard mask over the first hard mask, prior to patterning the first hard mask, wherein patterning the first hard mask further comprises patterning the third hard mask.

18. The method according to Claim 17, wherein depositing the third hard mask comprises depositing SiO₂.

19. The method according to Claim 13, wherein depositing the third insulating layer comprises depositing the same material as the second hard mask material.

20. The method according to Claim 13, wherein depositing the third insulating layer comprises depositing the third insulating layer in a thickness greater than the top surface of the first hard mask.

21. The method according to Claim 13, further comprising:

depositing a fourth insulating layer over the first hard mask top surface and the third insulating layer; and

forming at least one second conductive line in the fourth insulating layer, wherein the at least one second conductive line makes electrical contact to an upper portion of the magnetic memory cell.

22. The method according to Claim 13, wherein depositing the soft layer material comprises depositing a first magnetic layer over the pinning layer, depositing a thin oxide layer over the first magnetic layer, and depositing a second magnetic layer over the thin oxide layer, wherein the at least one magnetic memory cell comprises a magnetic random access memory (MRAM) cell.

23. The method according to Claim 13, wherein at least a portion of the second hard mask remains residing over a top surface of the first hard mask and over sidewalls of the soft layer after patterning the pinning layer.

24. A magnetic memory device, comprising:

- a workpiece;
- at least one first conductive line disposed over the workpiece;
- a pinning layer coupled to the at least one first conductive line;
- a soft layer disposed over the pinning layer, the soft layer having sidewalls and comprising a magnetic memory cell;
- a first hard mask disposed over the soft layer, the first hard mask having substantially the same lateral dimensions as the soft layer, the first hard mask having sidewalls and a top surface, the first hard mask being conductive;
- a second hard mask disposed over the pinning layer, the top surface and sidewalls of the first hard mask, and over the sidewalls of the soft layer, wherein the second hard mask comprises substantially the same lateral dimensions as the pinning layer, wherein the second hard mask comprises SiC, SiON, SiCN or SiN;
- a first insulating layer disposed over at least the second hard mask, wherein the first insulating layer comprises SiC, SiON, SiCN or SiN; and
- at least one second conductive line disposed over and abutting the first hard mask, wherein the at least one second conductive line runs in a different direction than the at least one first conductive line.

25. The magnetic memory device according to Claim 24, wherein the soft layer and pinning layer comprise a magnetic tunnel junction, wherein the memory device comprises a magnetic random access memory (MRAM) device.

26. The magnetic memory device according to Claim 24, wherein the first hard mask comprises TiN.